WORK PLAN FOR THE SOLVENT EXTRACTION OF PCB-CONTAMINATED SOILS AT MINDEN, WEST VIRGINIA

Submitted to:

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PRELIMINARY DRAFT FOR
REVIEW PURPOSES

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1.0 INTRODUCTION

1.1 BACKGROUND

The Shaffer Equipment Company (SHAFFER) site is located on West Virginia Route 17 in Minden, West Virginia. Minden is a small coal town located in Fayette County with approximately 2,000 residents. There are an estimated 65 to 75 people who live within 1/8th mile of the site. SHAFFER has been in operation since 1970 building electrical substations for the local coal mining industry. Many of its units incorporate various sizes of transformers, capacitors, switches, and other voltage regulation/distribution devices. SHAFFER's past practices involved the storage of unneeded, damaged, or outdated transformers and capacitors on the site. Leakage from these units and associated storage practices appears to be responsible for the severe PCB contamination problem that currently exists on the site.

The site covers approximately 1 acre and contains a single building which is both a workshop/warehouse and office. The site is relatively flat and slopes toward the west. Arbuckle Creek is located downgradient and to the west and has been shown to contain PCBs in the sediment [194 parts per million (ppm)].

PCBs have been found in soils and sediments on site. Levels as high as 22 percent have been found in heavily stained soils. It is estimated that contaminated soil contains PCBs at levels in excess of 50 ppm. In addition, there were an estimated 150 transformers, 60 capacitors, and 75 drums on site. Labels were found which indicate that some transformers and capacitors were filled with PCB fluids.

PCB-bearing transformers, capacitors, and drums were recently removed from the site. The waste material was transported to the General Electric facility in Philadelphia, Pennsylvania. However, the United States Environmental Protection Agency (USEPA) is concerned about the appropriate methodology to handle/dispose of the remaining PCB-contaminated soil.

1.2 DISPOSAL ALTERNATIVES

In the cleanup of hazardous and industrial waste sites, large quantities of contaminated soil or sediments are usually present where waste products have been spilled or stored. Traditionally, two options are used for the disposal of contaminated soils. Highly contaminated materials were typically packaged and incinerated; soils with low to moderate concentrations were placed in secured hazardous waste landfills. Recent scientific studies have prompted

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concerns over the integrity of these landfills. These concerns are based on the wastes' long-term ability to alter the containment properties and possibly enhance leaching of contaminants to the surrounding soils and ground water. Recently, monitoring studies at these facilities have caused temporary shutdown or reduction in capacity and have resulted in a general trend for industry to seek alternate, more complete methods of treating these wastestreams since incineration alone would be economically unfeasible.

Current environmental regulations, i.e., the Resource Conservation and Recovery Act (RCRA), directly promotes resource conservation and recovery by the support of new and innovative technologies. Accordingly, USEPA Region III has undertaken an investigation of alternatives to conventional landfilling for the disposal of PCB-contaminated soil at the SHAFFER site.

This investigation led to the conclusion that solvent extraction is viable from technical feasibility, cost, and schedule standpoints. Consequently, in view of O.H. Materials Co.'s (OHM) ongoing investigations of the application of continuous, countercurrent extraction systems to treat PCB-contaminated soil as well as OHM's recent bench and pilot scale studies of the technical feasibility of solvent extraction at the SHAFFER site, USEPA Region III requested OHM to develop a work plan for use of a solvent extraction system at the site.

1.3 PURPOSE AND SCOPE

In response to the request of USEPA Region III, OHM presents this work plan for the operation of a solvent extraction process facility for the treatment of PCB-contaminated soils at the SHAFFER site. The project involves the full-scale application of a process developed and tested by OHM at the pilot and benchscale levels at the SHAFFER site during May and June 1985. The results of these studies have clearly indicated that this extraction procedure is technically capable of achieving PCB reductions in excess of 95 percent for single extractions, with higher efficiencies possible for multiple-pass systems over the range of influent PCB concentrations studied. A complete description of the test program and results is given in the OHM report entitled "Solvent Extraction of PCB-Contaminated Soils, Bench and Pilot Scale Tests (June 25, 1985)."

USEPA has requested that OHM develop its work plan based on the initiation of soil treatment at the site as soon as ~~reasonably practical~~. Consequently, some of the equipment and system concepts that are presented herein, while technically feasible and reasonable in cost, have been selected on the basis of their ~~ready availability as opposed to technical and cost optimization~~.

In the body of this document, a System Description of the treatment facility (Section 3.0), a Work Plan Task Description for its operation (Section 4.0), and the Project Schedule and Cost Estimate (Section 5.0) are presented. Section 2.0, Summary, contains a fact-sheet type presentation of the work plan's key aspects.

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2.0 SUMMARY

2.1 WORK PLAN BASIS

This work plan is based on the full-scale application of a process developed and tested by OHM at the bench and pilot scale levels at the SHAFFER site during May and June of 1985. These bench and pilot scale tests included the ~~continuous countercurrent extraction of PCB-contaminated soils~~ with several solvents including methanol and methanol/FREON TF mixtures. The results of these tests clearly indicated that this extraction procedure is technically sound and capable of achieving PCB reductions approaching ~~95 percent for single extractions~~, with higher efficiencies possible for multiple-pass systems over the range of PCB concentrations studied. ~~In terms of reduction efficiency, methanol alone was clearly found to be superior to FREON TF and FREON TF/methanol mixtures.~~

2.2 SYSTEM DESIGN CRITERIA

In developing the full-scale system, OHM based its design on the following criteria:

- Soil volume .... 4,100 cubic yards
- Soil density .... $1.1\ g/cm^3$
- Soil mass .... 7,600,000 lb.
- Calculated soil PCB concentration (average) .... 400 ppm
- Soil moisture content .... 15 percent
- PCB reduction efficiency required (average) .... 93.75 percent
- ~~Soil treatment rate .. design 10 tons per hour~~
- Selected solvent .... ~~methanol~~
- Number of solvent passes through extractor.. ~~4~~

2.3 OHM TREATMENT SYSTEM

A schematic diagram of the OHM treatment system is presented as Figure 1 (see Figure section). The major unit processes include:

- Soil Screening and Crushing - to reduce particle sizes to ~~less than 1 inch in diameter~~
- Soil Drying - to reduce soil moisture content to ~~less than one percent~~

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400 ppm
x .9375
375 ppm
25 ppm mean value

- Extraction ~~- to reduce~~ PCB concentration in soil by 93.75 percent
- Spent Solvent Sedimentation - to remove drag-out soils suspended in the spent solvent
- Spent Solvent ~~Carbon Adsorption~~ - to reduce PCB concentrations in spent solvent to enable its reuse
- Clean Soil Drying - to recover methanol contained in soil for reuse in extraction
- Methanol Condensation - to recover methanol vaporized in the clean soil drying process

2.4 EQUIPMENT

The major pieces of equipment that will be utilized include:

- Cage mill crusher
- HOLO-FLITE dryers
- Boiler
- Continuous countercurrent soil extractor
- Lamella solids separator
- Ultrafiltration vessels
- Air condenser unit

2.5 PROJECT SCHEDULE

The project schedule includes:

Tasks	Start Week Of	Duration
o Pre-mobilization	9-9-85	2 to 5 days
o Mobilization	9-16-85	1 day
o Site preparation	9-16-85	3 days
o System start up and testing	9-16-85	14 days
o Processing	9-30-85	23 days
o Decontamination and demobilization	10-21-85	7 days
o Site restoration	10-28-85	2 days
o Final demobilization	11-4-85	1 day

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2.6 SCHEDULE ASSUMPTIONS

Key assumptions utilized as the basis for the project schedule include:

- o Hours per shift - 24-hours-a-day operation during processing
  - 12-hours-a-day operation at all other times

- o Percent down time - 25 percent during processing

2.7 OHM ESTIMATED COST

The total estimated cost for the project in accordance with the schedule and assumptions presented above is $1,600,000. The major components are:

o Pre-mobilization	$ 10,000
o Mobilization	25,000
o Site Preparation	25,000
o System Set Up and Testing	145,000
o Processing	1,267,000
o Decontamination and Demobilization	110,000
o Site Restoration	10,000
o Final Demobilization	8,000
TOTAL	$1,600,000

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3.0 SYSTEM DESCRIPTION

3.1 INTRODUCTION

A number of unit processes have been identified as integral steps in the extraction procedure. By no means should these processes be interpreted as technically feasible at similar contaminated sites. They merely represent the optimization of system parameters for this particular location. These steps are given below:

- Soil Preparation
  - Screening to less than 8 inches
  - Crushing of soil fractions to less than 1 inch
  - Drying to remove entrained water
- Solvent Extraction
  - Continuous, countercurrent contacting
- Solvent Recovery/Processing for Reuse
  - Drying to recover methanol from soil exiting extractor
  - Sedimentation of suspended solids in extractor solvent
  - Ultrafiltration to trap submicron-sized particles
  - Activated carbon adsorption of PCBs from methanol

The solvent ultimately chosen for the proposed 10 TPH model was methanol, primarily due to cost considerations of the pure chemicals (see below).

Methanol	$0.105/lb
Freon 113	$ 1.10/lb

Source: Chemical Marketing Reporter, July 1985

Since the use of pure methanol raises issues concerning ~~explosive hazards~~ in and around the treatment equipment, it becomes necessary to incorporate ~~nitrogen purging in all process vessels which would contact methanol~~. This would result in nonexplosive atmospheres and hence reduce the likelihood of problems.

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Although the pilot tests conducted at the Minden site were limited to extractive trials, bench studies revealed information pertinent to the full-scale sizing of process systems. Each of the proposed processes is standard technology and therefore can be performed through the acquisition of related equipment.

3.2 SOIL PREPARATION

Contaminated soil will be loaded into a metering hopper in order to convey the soil to the treatment system at a fixed flowrate. This metering hopper will feed a cage mill crusher from which 8 inch+ size fractions have been previously removed. This basic separation is necessary so that the crusher will not jam with oversized material. The less than 8 inch fractions fall down a chute into the continuous cage mill crusher which will reduce all particles to less than 1 inch in diameter. This particle size is relevant to proper operation of the extractor and optimization of removal efficiencies.

Crushed material exits this unit and is conveyed to a HOLO-FLITE dryer where entrained water will be driven from the soil. Without this step, the water content of the recycled methanol would eventually increase to a point where it would interfere with the solvent extraction. Live steam will be utilized as the heating media and is supplied by a boiler maintained on site. All heating of the soil is accomplished through the use of a jacketed trough on the HOLO-FLITE so that the soil does not directly contact the steam. Condensate is returned to the boiler feed system. Sizing of this drying vessel is critical to ensure that the contaminated soil is free of moisture before extraction begins.

3.3 SOLVENT EXTRACTION

The dried soil then flows by gravity into a parallel arrangement of extractor cells, at a design processing rate of 10 TPH of contaminated soil. Each treatment circuit of this parallel arrangement consists of two cells coupled in series, for a total length of 34 feet. Trough diameter is a constant 30 inches. At this processing rate, an estimated 10 to 30 minutes of residence time can be achieved. These times are necessary in order to duplicate the removal efficiencies demonstrated in the pilot study and the 25 ppm PCB discharge criteria for soil.

retention time to do so?

Solvent usage in the parallel treatment arrangement is estimated as a total of ~~38 to 55 gallons per minute of methanol~~. Following initial contact with the soil in the extractor, solids are removed from the solvent stream via a sedimentation vessel and ultra-filtration vessels. The solids-free solvent is recycled back to the solvent feed

- Gaskets compatible w/ MeOH

enough other solvent available?

less of MeOH in carbon or transfers. Could spillage occur?

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How will we know that MeOH is saturated?
Efficiency -vs- cost of extraction thru carbon

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on closed system

tank for reuse in the extractor cells. This procedure is continued until the ~~methanol can no longer extract PCBs from~~ the influent soil. The spent solvent is then pumped through ~~activated carbon cells~~ which adsorb PCBs from the methanol.

Concentrating the PCBs in the methanol in this manner will result in higher observed weight loadings on the activated carbon, which ultimately leads to cost savings for newly purchased activated carbon.

loading rate of carbons

During this adsorption process the extractor cells are being replenished with fresh solvent from a second storage tanker so that processing can proceed uninterrupted. Removal of both water and PCBs ensures that minimum purchases of methanol are needed for the project.

As mentioned earlier, certain safeguards must be included in this proposed system to minimize the possibility of an explosion within all process vessels. Methanol can explode if its concentration in air is between 6 and 30 percent. This extraction system incorporates ~~rotary air valves on both the upstream and downstream ends of the contactor as part of the nitrogen purging package~~. Nitrogen gas is piped to the upstream air lock and maintained at a slight positive pressure (1 to 2 inches W.C.) to prevent air from entering. This eventually purges any oxygen from the system and replaces it with nitrogen, which is an inert gas. ~~Sensors will continuously monitor the level of oxygen in this and other process equipment and in turn will control the feed rate of nitrogen that is needed to provide an inert atmosphere.~~

Quantity of Nitrogen predicted?

What Nitrogen concentrations are toxic?

3.4 SOLVENT RECOVERY PROCESSING

While methanol appears inexpensive on a per-pound basis, the purchased chemical cost necessary to treat 4,100 cubic yards of contaminated soil is a staggering $1,000,000 to $2,000,000 if fresh solvent is continuously used. Therefore, solvent recovery and processing for reuse appears extremely advantageous from a standpoint of both materials handling and dollars saved for expendables. Two recovery processes were scrutinized for technical and economic viability, a) on-site distillation of the methanol/PCB mixture, and b) extraction of the PCBs from the methanol using fixed-bed techniques i.e. activated carbon adsorption. Distillation appeared as a viable alternative, but the 8 month delivery for equipment and enormous size (up to 10 feet diameter and 10 feet tall) and tremendous energy requirements (up to 50,000,000 Btu/hr) eliminated this idea. Granular activated carbon adsorption of the PCBs from the methanol requires virtually no energy and has been demonstrated feasible in laboratory studies. An estimated 95,000 pounds of

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~~virgin carbon would likely by necessary over the life of the project.~~ These values are based upon the following assumptions:

- o Volume of contaminated soil .... 4,100 yd^3
- o Average PCB concentration .... 400 mg/kg
- o Estimated effluent concentration .... 25 mg/kg
- o Specific gravity of soil .... 1.1 g/cm^3
- o Total mass of soil .... 7,600,000 pounds
- o Calculated mass of PCBs .... 3,040 pounds

Before implementing such a carbon adsorption system it would be ~~necessary to remove the soil fines from the methanol.~~ These fines are carried over from the extractor and clearly represent a threat to the life of the carbon if not removed. The proposed recovery system incorporating these ideas will entail the use of a ~~slant tube clarifier to remove the vast majority of solids,~~ followed by ~~ultrafiltration for polishing.~~ All ~~fines collected through sedimentation would be recycled back to the extractors for reprocessing. Disposable cartridges or bags could be utilized in the ultrafiltration vessel.~~ Most of the equipment in the solvent recovery system can be supplied or fabricated by OHM.

Quantity disposal filters

A significant cost savings could also be realized by collecting the methanol trapped in the washed soil as it leaves the extractor. Although free liquids have been drained from the soil, the moisture content still could be as high as 25 percent as observed in the pilot study. This translates to a loss of $75,000 to $250,000 in methanol due to make up requirements if this is allowed to evaporate.

The proposed treatment system incorporates a stainless steel HOLO-FLITE dryer to remove methanol from the washed soil. Live steam is used to heat the jacket and screw of this unit to the boiling point of the methanol. Nitrogen is used to initially purge oxygen from the system and create positive pressure so that air cannot enter. The methanol vapors are routed to an air condenser where the relatively pure liquid is collected after condensation and recycled to the storage tanks. This solvent is blended with fresh stock for reuse in the extractors.

Methanol collection efficiency in the HOLO-FLITE dryer should exceed 95 percent, based upon 10 percent (w/w) methanol in the effluent soil. This leaves an estimated 0.5 percent methanol in the clean soil. The soil, now dry, can be transported to a suitable holding area for analysis.

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4.0 WORK PLAN TASK DESCRIPTION

The operational work plan developed for the SHAFFER site has been organized into five major phases: Mobilization, Set-up, Operation, Decommissioning, and Demobilization. Each phase has various tasks associated with it as described below.

4.1 MOBILIZATION

The initial mobilization task for the SHAFFER site will consist of a site visit by the OHM project supervisor, project control technician, and a civil/structural engineer. Those personnel will arrive on-site approximately 2 weeks prior to the major mobilization effort. The purpose of this visit is to arrange for utility connections with the process system, set-up contractual arrangements for the construction of the concrete or asphalt containment areas for the process system (based on cost-effectiveness), and inspection and fortification (as necessary) for the access bridges over Arbuckle Creek. The bridge fortification may be necessary depending upon the gross vehicle weight of the trucks carrying the extraction equipment. The major mobilization effort will be coordinated with these personnel on site so as to assure an expeditious set-up period.

The personnel and equipment to be utilized at the SHAFFER site will be mobilized from the OHM corporate headquarters located in Findlay, Ohio. The major mobilization effort will be made in three waves to provide equipment for the tasks as necessary but cost-effectively. This will minimize having any unnecessary equipment on site before it is actually needed.

The first wave mobilization will provide personnel and equipment for site preparation and the set-up of the soil extraction equipment. The second wave mobilization will provide personnel and testing equipment required for the actual startup and on-site shakedown of the soil extraction equipment. The third wave mobilization will provide the remaining personnel and equipment for the full-scale operation of the process on site.

Most personnel and equipment will be mobilized by highway from Findlay to Minden and the first wave mobilization will be the largest. Additional personnel will be flown commercially on an as-needed basis. The first wave mobilization has been tentatively planned for the week of September 16, 1985.

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4.2 SET-UP

The set-up phase of the project has been organized into two major tasks: Site Preparation and System Startup/ Shakedown.

4.2.1 Site Preparation

The site preparation will begin with the set-up of the support area and staging of the support equipment. This includes the decontamination trailer, the mobile laboratory, and the office trailers. Concurrently, an inspection check and repair will be made to the site exclusion fence and gates. After these initial tasks, preparation will be made to the areas on site designated to house the soil extraction process and the tank-truck product transfer area. Basically, these containment areas will consist of a compacted base covered with either concrete or asphalt depending on cost-effectiveness. These slabs will be finished off with perimeter berms and have a slight depression located at one corner for a product collection point. The purpose of these containment areas is to provide a foundation to support the heavy process equipment and to provide a containment contingency in the event that there is an unanticipated release of solvent. These equipment pads will also house some of the safety equipment required for on-site operation such as the liquid nitrogen tank used to purge the process equipment.

During these site preparation tasks, OHM personnel will brief USEPA on the details of the process. Jointly, both groups will then formulate the site safety and contingency plans for use during operation. Communication networks will link the project to other involved local parties. The final site preparation step is to establish the site security plan.

4.2.2 System Startup/Shakedown

At this point, the soil extraction system will be assembled and connections leak tested using dry nitrogen initially. After the system has been leaked tested, the final safety, contingency, and operation instructions will be issued to all personnel on site. At this point, the system will begin its testing and calibration phase using methanol solvent and clean, uncontaminated soil. This procedure will allow preliminary calibration of flow rates and instrumentation. At the end of the shakedown, last minute adjustments will be made and final instructions issued to all personnel. The system is now ready for operation.

4.3 SYSTEM OPERATION

The system operation is organized into several entities. Basically, a Caterpillar 930 loader will remove soil from the contaminated pile and place it into the crushing/ screening hopper. At that point, the soil processing is fully automated and is described in detail in Section 3.0. Once the cleaned, dry soil exits the process, it is collected with front bucket tractor and placed into the soil staging area for testing. Samples of this soil (as with samples of the solvent from the process) will be analyzed on site by the mobile laboratory. All samples will be analyzed by Gas Chromatography (GC) as per USEPA consensus methodology. The sampling schedule will facilitate verification of the extraction efficiencies and allow the process throughout to be optimized. All materials will be tested before redistribution on site or in the case of expendables (e.g., carbon and spent solvents), will be analyzed prior to transportation and disposal. USEPA will perform all perimeter air monitoring and OHM will continually immediately adjoining the system.

Specially trained personnel will operate the system. Dedicated foremen, process engineer, chemists, and technicians will be used during each shift of operation. Senior technical corporate staff will also be present during crucial operations and will make regular, periodic visits to check on the operation.

The general description of the system operation will be further detailed and refined for on-site operational procedures during future joint meetings with USEPA prior to any mobilization. This will assure the successful completion of the project in a timely and cost-effective manner.

4.4 DECONTAMINATION AND DEMOBILIZATION

The final disposal of spent solvent and carbon will occur after all nonessential equipment has been decontaminated and demobilized. Final disposal of the spent carbon will be incinerated, while disposal of the methanol is dependant on a variety of factors available for minimizing final costs. The cost for incineration at an approved site could range from $0.35/gallon down to an even trade-off for transportation costs because of its high Btu content. This high Btu content of methanol makes it attractive as a fuel for unit processes.

4.5 SITE RESTORATION

Site restoration will be conducted according to USEPA specifications, as yet to be determined.

4.6 FINAL DEMOBILIZATION

Final demobilization of personnel and equipment will occur once site restoration has been completed under the direction of the On-Scene Coordinator.

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5.0 PROJECT SCHEDULE AND COST ESTIMATE

5.1 ASSUMPTIONS

The following assumptions were used in the derivation of the project schedule and cost estimate:

- Final soil treatment criteria .... 25 ppm or less
- Soil volume .... 4,100 yd^3
- Soil density .... 1.1 g/cm^3
- Influent soil moisture content .... 15 percent by weight
- Average PCB concentration in soil .... 400 ppm
- Design solvent to soil ratio 0.75:1
- Estimated solvent life .... 4 passes
- Solvent drag out in soil .... 10 percent by weight in soil
- Effluent soil moisture content after drying .... Less than 0.5 percent in soil
- Design processing rate ..... 10 tons per hour

Actual performance values will be optimized on site but are dependent on actual soil conditions at the time of operation.

The design of drying and condensation systems has incorporated appropriate heat transfer values based upon standard values obtained from literature. The system was engineered for a design processing rate of 10 tons per hour. Actual performance will vary due to site conditions.

5.2 PROJECT SCHEDULE

Tasks	Week of	Duration
Pre-mobilization	9-09-85	2 to 5 days
Mobilization	9-16-85	1 day
Site preparation	9-16-85	3 days

Tasks	Week of	Duration
System start up and testing	9-16-85	14 days
Processing	9-30-85	23 days
Decontamination and Demobilization	10-21-85	7 days
Site restoration	10-28-85	2 days
Final demobilization	11-04-85	1 day

5.3 COST ESTIMATE

Pre-mobilization	$ 10,000
Mobilization	25,000
Site Preparation	25,000
System Startup and Testing	145,000
Processing	1,267,000
Decontamination and Demobilization	110,000
Site Restoration	10,000
Final Demobilization	8,000
TOTAL ESTIMATE COST	$1,600,000